A CIRCUIT APPROACH TO THE ANALYSIS OF A TWO STAGE DYNAMO-ELECTRIC AMPLIFIER

By

ROGER WILLIAM BURTNESS

B. S., University of Illinois, 1946

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In recent years the direct current dynamo has been used in many applications as an amplifier in a dynamic control system. Control of speed, acceleration, and deceleration necessitates feedback circuits, stabilizing devices, and high amplification in machines. To produce a dynamo with higher amplification and better frequency response, the "amplidyne", "regulex", and "rototrol" have been developed. The regulex and rototrol may be thought of as special cases of a standard direct current dynamo. An amplidyne, however, is a type of two stage dynamo-electric amplifier as are Rosenberg generators and certain metadynes.

At the present time there are many articles* available on the general design, operation, and applications of the amplidyne. The articles** which contain analysis, however, are rather limited. The articles which have been written are primarily for use in network synthesis and thus contain only a minimum of analysis of the amplidyne itself.

In order to analyze the amplidyne more thoroughly, and at the same time make the analysis such that it can easily be used for network synthesis, the coupled circuit approach can be utilized to full advantage. A system of matrix algebra is used to facilitate writing equations and to give order to complex mathematical manipulation. Thus it becomes possible to consider the short-circuited turns due to commutation and not neglect them

as is usually done.

The thesis is then an extension of the coupled circuit approach into the area of the two stage dynamo-electric amplifier. The common case of the commutator segments being a multiple of four, and the brush width being equal to one commutator segment plus twice the width of the insulation between segments, is chosen for analysis. Saturation and hysteresis are considered negligible in the analysis, but considered qualitatively in the experimental discussion. The differential equations which are developed are general for any type of load impedance or input voltage. These variable coefficient linear differential equations are then transformed into linear differential equations with constant coefficients which can be solved by standard methods.

With the equations presented, it is then possible to determine the complete transient and steady state response under any condiion of load, or any input voltage function. The transfer function of the two stage dynamo-electric amplifier is also obtained and the frequency response is given. With the aid of a computer, a complete study of the operation of the machine could be made.

The analysis presented points out not only the two primary time constants of the machine, but three others as well. One of the primary time constants is essentially that of the main control field. The other primary time constant is smaller than that of the armature quadrature axis principally because of the influence of the direct axis short-circuited turns. It is concluded that neglecting the armature short-circuited turns due to commutation leads to serious error in the value of the armature

time constant.

Experimental data are taken on an amplidyne and the response of the amplidyne to a step function input is predicted. The frequency response of the amplidyne is also predicted. The actual curves agree with the predicted curves within the limits of experimental accuracy. Particular difficulty was encountered in the measurement of certain inductances including that of the main control field. The method of obtaining these measurements is discussed.

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VITA

Roger William Burtness was born on May 13, 1925, in Chicago, Illinois. After graduating from Oak Park-River Forest Township High School in 1943, he entered the United States Navy and subsequently was sent to the University of Illinois in the V-12 program. He received the degree of Bachelor of Science in Electrical Engineering from that institution in June, 1946. After his discharge from the Navy he entered St. Olaf College and in June, 1947, he received the degree of Bachelor of Arts with a major in Economics from that institution. In August, 1947, he joined the General Electric Company where he worked for two years. In September, 1949, he entered the Graduate College of the University of Illinois. In February, 1951, he received the degree of Master of Science in Electrical Engineering from that institution. He held a teaching assistantship from September, 1949, to September, 1952. In September, 1952, he was appointed to the position of instructor in the Electrical Engineering Department.

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